Expert's opinion
Fire resistance

Müpro anchors in hollow core slabs

valid for

Steel anchor

Nail anchor
Type MKT Nail anchor

Hollow-core slab ceiling anchor
Type MKT Easy
(selected sizes)

MFPA Leipzig GmbH

Testing, Inspection and Certification Authority for
Construction Products and Construction Types

Leipzig Institute for Materials Research and Testing
Business Division III - Structural Fire Protection
Dipl.-Ing. Sebastian Hauswaldt

Work Group 3.2 - Fire Behaviour of Building Components and special Constructions
Dipl.-Ing. S. Bauer
Tel.: +49 (0) 341-6582-194
s.bauer@mfpa-leipzig.de

Advisory Opinion No. GS 3.2/17-250-1 Ä
Replacement for: GS 3.2/17-250-1 dated 01. August 2017

31 August 2017
No. Copy 1

Subject matter:	Determination of the characteristic fire resistance parameters under tensile stress according to the Technical Report TR 020 "Evaluation of Anchorages in Concrete concerning Resistance to Fire" (May 2004) for the MÜPRO Steel Anchor with shoulder, the MKT Nail Anchor N and the MKT hollow-core anchor EASY for use in slabs with void formers.
Client:	MÜPRO Services GmbH Hessenstraße 11 65719 Hofheim-Wallau Germany
Date of order:	27 July 2017
Person in charge:	Dipl.-Ing. S. Bauer
Validity:	31 July 2022

This advisory opinion consists of 7 pages and 1 enclosure.

Gesellschaft für Materialforschung und Prüfungsanstalt für das Bauwesen Leipzig mbH (MFPA Leipzig GmbH)

Head Office: Hans-Weigel-Str. 2b – 04319 Leipzig/Germany
Managing Director: Prof. Dr.-Ing. Frank Dehn
Comm. Register: Local Court Leipzig HRB 17719
VAT-ID: DE 813200649
Tel.: +49 (0) 341-6582-0
Fax: +49 (0) 341-6582-135

1 Objective and request

On 27 July 2017, MFPA Leipzig GmbH was commissioned by MÜPRO Services GmbH with the assessment of the resistance to fire of the MÜPRO Steel Anchor with shoulder, the MKT Nail Anchor N and the MKT hollow-core anchor EASY with fire exposure from one side and anchored to a reinforced concrete base and a base made of reinforced concrete slabs with void formers (e. g. Cobiax system) to determine the characteristic parameters for the structure under tensile stress.

2 Description of the tested constructions

In the following assessment, the MÜPRO Steel Anchor with shoulder, the MKT Nail Anchor N and the MKT hollow-core anchor EASY are considered.

A detailed product description for the MÜPRO Steel Anchor with shoulder can be found in the European technical assessment ETA-05/0161 [1]. The following sizes are assessed:

- M8 x 30
- M10 x 30
- M6x25, M8x25, M10x25, M12x25.

The product description for the MKT Nail Anchor N can be found in ETA-11/0240 [2]. The following versions are assessed in this document:

- N 6 x 25 (all versions)
- N 6 x 30 (all versions).

For a detailed description of the MKT hollow-core anchor EASY, refer to the general building inspectorate approval Z-21.1-1785 [3]. Here, the EASY M8 will be considered in particular.

For images of the individual types of anchors when installed and the installation parameters, refer to Enclosure 1. All the tests were performed and analysed according to TR 020: 2004-05 [4]. The test description and the corresponding analysis can be found in GS 3.2/17-069-2 [5].

The use of all tested structures in reinforced concrete slabs with void formers was already confirmed for the cold state in 710/17_21723_1 [6]. In this advisory opinion, only the fire resistance parameters in slabs with void formers are therefore considered in the following.

3 Test analysis and assessment of slabs with void formers

A specific consideration of slabs with void formers is required since the thermal conduction is impaired by the void formers which leads to higher part temperatures on the side facing the fire than in case of a solid slab without void formers. This means that it is more difficult for the steel part which is exposed to the fire to transfer the heat to the concrete. This in turn leads to an earlier through heating of the steel part and may lead to earlier steel failure.

In addition, the advisory opinion 710/17_21723_1 [6] demands that if the above-mentioned anchors are used in slabs with void formers, the face thickness that is certain to remain must correspond to the anchoring depth which is to be assessed. According to 710/17_21723_1 [6], this is achieved by observing a minimum face thickness underneath the void formers. The minimum face thickness is calculated using the required minimum anchoring depth h_{nom} of the corresponding anchor plus a safety margin of 10 mm for the positional tolerances of the void formers plus an additional safety margin of 20 mm to ensure a sufficient residual face thickness if the concrete cracks in the direction of the void former during drilling.

To facilitate an assessment of the MÜPRO anchors and the MKT anchors in slabs with void formers, a design was selected from a series of Cobiax slabs the bottom face of which heats up most quickly during fire exposure according to the standard temperature-time curve (ETK). The selected design was type SLIM-Line S-100. This type of slab was assessed in face thicknesses of 50 mm, 60 mm, 80 mm and 100 mm. The temperatures inside these slabs with void formers were compared to the temperatures in a solid slab.

As a first step, it was tested to what extent loads have to be reduced for use in slabs with void formers if only the minimum face thickness according to the advisory opinion 710/17_21723_1 [6] is available.

For the results of this analysis, refer to Table 1 to Table 4.

Table 1 *Admissible load for the MÜPRO Steel Anchor with shoulder for use in slabs with void formers with the minimum face thickness*

Size	h_{ef} [mm]	Min. face thickness [mm]	F30 Load [kN]	F60 Load [kN]	F90 Load [kN]	F120 Load [kN]
M6	= 25	60	0.41	0.29	0.24	0.20
M8	≥ 25	60	1.13	0.68	0.45	0.33
M10	= 25	60	0.56	0.56	-	-
M10	= 30	60	1.96	1.08	0.73	0.51
M12	= 25	60	0.56	0.56	-	-

Table 2 *Admissible load for the MKT Nail Anchor N made of galvanised steel (≥4.8) for use in slabs with void formers with the minimum face thickness*

Size	h_{ef} [mm]	Min. face thickness [mm]	F30 Load [kN]	F60 Load [kN]	F90 Load [kN]	F120 Load [kN]
N6 N8	≥ 25	60	0.69	0.46	0.34	0.28
N-K		60	1.30	0.77	0.50	0.36
N-M		60	0.69	0.46	0.34	0.28
N-O		60	0.25	0.16	0.12	0.09
N6 N8	≥ 30	60	0.69	0.46	0.34	0.28
N-K		60	1.30	0.77	0.50	0.36
N-M		60	0.69	0.46	0.34	0.28
N-O		60	0.25	0.16	0.12	0.09

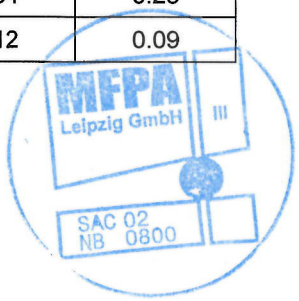


Table 3 *Admissible load for the MKT Nail Anchor N made of stainless steel (A4/HCR) for use in slabs with void formers with the minimum face thickness*

Size	h_{ef} [mm]	Min. face thickness [mm]	F30 Load [kN]	F60 Load [kN]	F90 Load [kN]	F120 Load [kN]
N6-A4/HCR N8-A4/HCR	≥ 25	60	0.69	0.46	0.34	0.28
N-K-A4/HCR		60	1.30	0.77	0.50	0.36
N-M-A4/HCR		60	0.69	0.46	0.34	0.28
N-O-A4/HCR		60	0.25	0.16	0.12	0.09
N6-A4/HCR N8-A4/HCR	≥ 30	60	1.89	0.91	0.53	0.28
N-K-A4/HCR		60	2.31	1.05	0.56	0.25
N-M-A4/HCR		60	1.89	0.91	0.53	0.28
N-O-A4/HCR		60	0.25	0.16	0.12	0.09

Table 4 *Admissible load for the MKT hollow-core anchor EASY (≥5.8) for use in slabs with void formers with the minimum face thickness*

Size	h_{nom} [mm]	Min. face thickness [mm]	F30 Load [kN]	F60 Load [kN]	F90 Load [kN]	F120 Load [kN]
M8	≥ 45	80	0.83	0.65	0.52	0.47

As a second step, it was tested at which face thickness the temperatures in the slab with void formers closely correspond to the temperatures in the solid ceiling. The goal was to maintain the characteristic loads from the massive ceilings as accurately as possible. It was found that with short ETK durations and high face thicknesses, the temperatures underneath the void formers closely correspond to the temperatures at the same point in a solid ceiling. With longer fire resistance periods, so much more heat builds up underneath the void formers than underneath a solid ceiling that the loads have to be reduced in comparison to the results for solid ceilings.

With higher fire resistance classes, however, the temperatures in the slab with void formers also considerably deviate from the temperatures in a solid ceiling with a large bottom concrete face of 100 mm. This is why the loads for F90 and F120 had to be partially reduced.

In the following Table 5 to Table 8, the maximum loads with higher face thickness are specified. The safety margin for positional tolerances of the void formers and rear concrete failure were taken into account.

Table 5 *Required face thickness and admissible load for the MÜPRO Steel Anchor with shoulder for use in slabs with void formers*

Size	h_{ef}	F30		F60		F90		F120	
		Min. face thickness	Charact. load	Min. face thickness	Charact. load	Min. face thickness	Charact. load	Min. face thickness	Charact. load
	[mm]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]
M6	= 25	60	0.41	80	0.35	100	0.28	100	0.25
M8	≥ 25	60	1.13	80	0.88	100	0.63	100	0.51
M10	= 25	60	0.56	80	0.56	100	0.56	100	0.45
M10	= 30	60	1.96	80	1.53	100	1.09	100	0.87
M12	= 25	60	0.56	80	0.56	100	0.56	100	0.45

Table 6 *Required face thickness and admissible load for the MKT Nail Anchor N made of galvanised steel (≥4.8) for use in slabs with void formers*

Size	h_{ef}	F30		F60		F90		F120	
		Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load
	[mm]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]
N6 **N8**	≥ 25	60	0.69	80	0.56	100	0.43	100	0.37
N-K		60	1.30	80	1.01	100	0.72	100	0.57
N-M		60	0.69	80	0.56	100	0.43	100	0.37
N-O		60	0.25	80	0.20	100	0.15	100	0.13
N6 **N8**	≥ 30	60	0.69	80	0.56	100	0.43	100	0.37
N-K		60	1.30	80	1.01	100	0.72	100	0.57
N-M		60	0.69	80	0.56	100	0.43	100	0.37
N-O		60	0.25	80	0.20	100	0.15	100	0.13

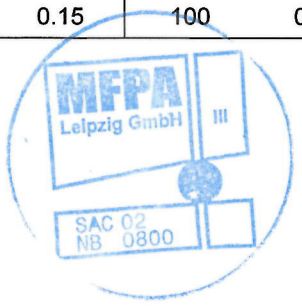


Table 7 *Required face thickness and admissible load for the MKT Nail Anchor N made of stainless steel (A4/HCR) for use in slabs with void formers*

Size	h_{ef}	F30		F60		F90		F120	
		Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load
	[mm]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]
N6-A4/HCR N8-A4/HCR	≥ 25	60	0.69	80	0.56	100	0.43	100	0.37
N-K-A4/HCR		60	1.30	80	1.01	100	0.72	100	0.57
N-M-A4/HCR		60	0.69	80	0.56	100	0.43	100	0.37
N-O-A4/HCR		60	0.25	80	0.20	100	0.15	100	0.13
N6-A4/HCR N8-A4/HCR	≥ 30	60	1.89	80	1.41	100	0.93	100	0.69
N-K-A4/HCR		60	2.31	80	1.69	100	1.07	100	0.76
N-M-A4/HCR		60	1.89	80	1.41	100	0.93	100	0.69
N-O-A4/HCR		60	0.25	80	0.20	100	0.15	100	0.13

Table 8 *Required face thickness and admissible load for the MKT hollow-core anchor EASY (≥5.8) for use in slabs with void formers*

Size	h_{nom}	F30		F60		F90		F120	
		Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load	Min. face thickness	Load
	[mm]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]	[mm]	[kN]
M8	≥ 45	80	0.83	100	0.71	100	0.60	100	0.48

4 Special notes

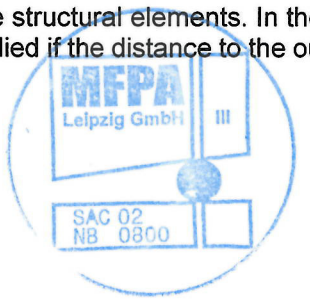
The above assessment only applies to the MÜPRO Steel Anchor with shoulder, the MKT Nail Anchor N and the MKT hollow-core anchor EASY that were installed in compliance with the installation regulations of the companies MÜPRO Services GmbH and MKT Metall-Kunststoff-Technik GmbH & Co. KG or a general building inspectorate approval or European Technical Assessment.

Furthermore, the assessment only applies to anchors with the specified minimum tensile strengths. Transferring the results for galvanised steel to A4 stainless steel and high corrosion resistance steel HCR (for the Nail Anchor) are possible due to the more favourable behaviour at high temperatures.

The assessment only applies to the use in uncracked reinforced concrete. For use in cracked concrete, the specified values have to be multiplied by 0.75.

For use in slabs with void formers, the specified minimum concrete cover of the void formers and the possibly reduced maximum loads have to be observed.

The assessment applies in general to a one-sided fire loading of the structural elements. In the event of a fire load on several sides, the verification procedure can only be applied if the distance to the outer edge of the anchor is c ≥ 300 mm and ≥ 2 hef.



Based on this, the specified loads also apply to lateral tension and/or diagonal tension.

The assessment only applies in conjunction with reinforced concrete ceilings of strength class ≥ C 20/25 and ≤ C 50/60 acc. to DIN EN 206: 2014-07 [7] that have at least the same fire resistance rating as the fire-resistance period of the anchors. In addition, the notes contained in DIN EN 1992-1-2: 2010-12 [8] (see section 4.5) on the avoidance of concrete spalling apply. This means that the moisture content must be less than three % by weight (or four according to the National Annex).

This document does not replace a certificate of conformity or suitability according to national and European building codes.

Leipzig, 31 August 2017

Dipl.-Ing. S. Hauswaldt	Dipl.-Ing. M. Juknat	Dipl.-Ing. S. Bauer
Head of Business Division	*Head of Work Group*	*Testing Engineer*

List of enclosures

Enclosure 1 Installation parameters of the tested MÜPRO Steel Anchor with shoulder, MKT Nail Anchor N and MKT hollow-core anchor EASY

Corresponding documents

[1] European Technical Assessment ETA-05/0161, product name: MÜPRO Steel Anchor, DIBt: 7. April 2017, MÜPRO Services GmbH

[2] European Technical Approval ETA-11/0240, product name: MKT Nail Anchor N, DIBt: 7. Mai 2015, MKT Metall-Kunststoff-Technik GmbH & Co. KG

[3] Z-21.1-1785, product name: MKT EASY, DIBt: 18. August 2016, MKT Metall-Kunststoff-Technik GmbH & Co. KG

[4] TR 020: 2004-05 Evaluation of Anchorages in Concrete concerning Resistance to Fire

[5] Advisory opinion GS 3.2/17-069-2, MFPA Leipzig GmbH: 10. Juli 2017

[6] 710/17_21723_1, Ingenieurbüro Thiele GmbH: 10. Mai 2017, MÜPRO Services GmbH

[7] DIN EN 206: 2014-07 Concrete - Specification, performance, production and conformity

[8] DIN EN 1992-1-2: 2010-12 Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design

Enclosure 1 Installation parameters of the tested MÜPRO Steel Anchor with shoulder, MKT Nail Anchor N and MKT hollow-core anchor EASY

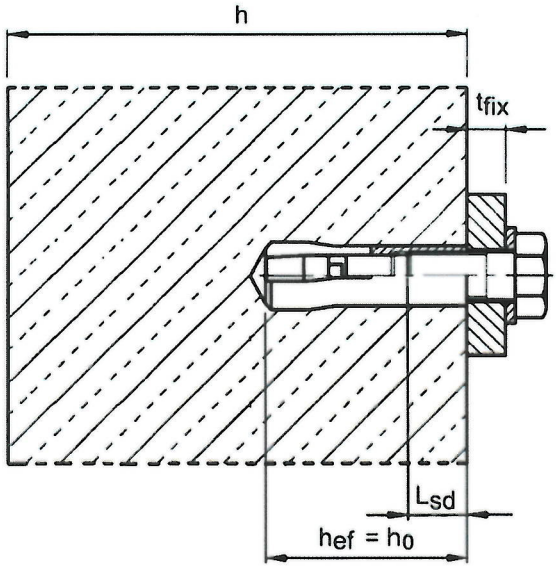


Figure A1.1 Installation situation of the MÜPRO Steel Anchor with shoulder

Table A1.1 Installation and anchor parameters for the MÜPRO Steel Anchor with shoulder with an installation depth of 25 mm

Anchor size			**M6x25**	**M8x25**	**M10x25**	**M12x25**
Depth of drill hole	h_0 =	[mm]	25	25	25	25
Drill hole diameter	d_0 =	[mm]	8	10	12	15
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8,45	10,45	12,5	15,5
Max. recommended installation torque	$T_{inst} \leq$	[Nm]	4	8	15	35
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	7	9	12	14
Available thread length	L_{th}	[mm]	12	12	12	12
Minimum screw-in depth	L_{sdmin}	[mm]	6	8	10	12
Minimum thickness of member	$h_{min,1}$	[mm]	**80**			
Minimum spacing	s_{min}	[mm]	30	70	70	100
Minimum edge distance	c_{min}	[mm]	60	100	100	130
Standard thickness of member	$h_{min,2}$	[mm]	**100**			
Minimum spacing	s_{min}	[mm]	30	50	60	100
Minimum edge distance	c_{min}	[mm]	60	100	100	110
Installation in precast pre-stressed hollow core slabs C30/37 to C50/60						
Spacing	s_{min}	[mm]	200			
Edge distance	c_{min}	[mm]	150			

Table A1.2 Installation and anchor parameters for the MÜPRO Steel Anchor with shoulder with an installation depth of 30 mm

Anchor size			**M8x30**	**M10x30**
Depth of drill hole	h_0 =	[mm]	30	30
Drill hole diameter	d_0 =	[mm]	10	12
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	10,45	12,5
Max. recommended installation torque	$T_{inst} \leq$	[Nm]	8	15
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	9	12
Available thread length	L_{th}	[mm]	13	12
Minimum screw-in depth	L_{sdmin}	[mm]	9	10
Steel, zinc plated				
Minimum thickness of member	h_{min}	[mm]	100	120
Minimum spacing	s_{min}	[mm]	60	100
Minimum distance	c_{min}	[mm]	95	115
Stainless steel A4, HCR				
Minimum thickness of member	h_{min}	[mm]	100	-
Minimum spacing	s_{min}	[mm]	60	-
Minimum distance	c_{min}	[mm]	95	-

Provided by the client.

MFPA Leipzig GmbH
SAC 02
NB 0800

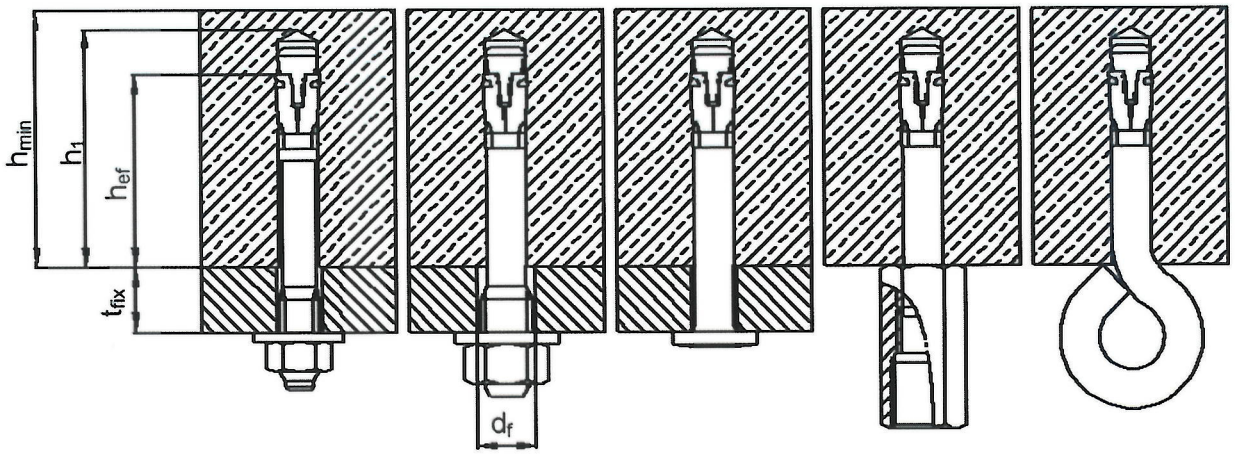


Figure A1.2 Installation situation of the MKT Nail Anchor N and representation of the different head designs

Table A1.3 Installation and anchor parameters for the MKT Nail Anchor N

Anchor type			**N 6 N-K N-O**	**N 8 N-M**	**N 6 N-K N-O**	**N 8 N-M**
Effective anchorage depth	$h_{ef} \geq$	[mm]	**25** [1]		**30**	
Nominal drill hole diameter	d_0	[mm]	6	6	6	6
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	6,40	6,40	6,40	6,40
Depth of drill hole	$h_1 \geq$	[mm]	35	35	40	40
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	7	9	7	9
Maximum tightening torque (N 6 and N 8 only)	$T_{inst} \leq$	[Nm]	4	4	4	4
Minimum member thickness	h_{min}	[mm]	80	80	80	80

[1] Internal use only

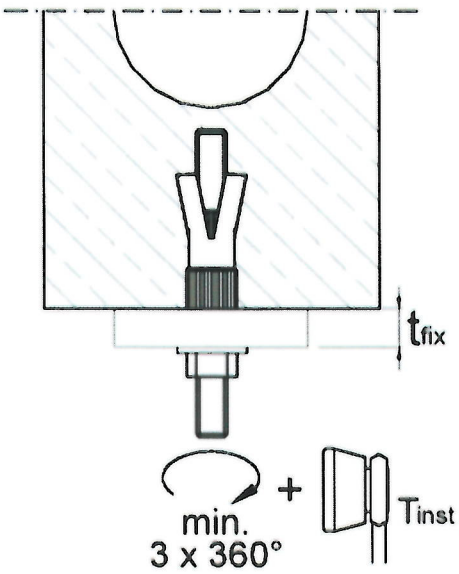


Figure A1.3 Installation situation of the MKT hollow-core anchor EASY

Table A1.4 Installation and anchor parameters for the MKT hollow-core anchor EASY

Anchor size			**M8**
Nominal drill hole diameter	d_0	[mm]	12
Cutting diameter of drill bit	d_{cut}	[mm]	12,5
Depth of drill hole	$h_0 \geq$	[mm]	55
Screw length (in solid material)	min l_s	[mm]	47 + t_{fix}
	max l_s	[mm]	55 + t_{fix}
Threaded rod length	min l_b	[mm]	53 + t_{fix}
Installation torque	T_{inst}	[Nm]	20
Diameter of clearance hole in the fixture	$d_f \leq$	[mm]	9
Design bending resistance	P.cl. 5.8[1]	[Nm]	15,0
	P.cl. 8.8[1]	[Nm]	23,9

[1] Labelling, see Table 1